

## CLAIMS

1. A process for producing a phosphonium borate compound, which comprises:

5 reacting a phosphine with HCl to produce a phosphine hydrochloride, the phosphine being represented by Formula (II):



10 wherein  $R^1$  is a primary alkyl group of 1 to 20 carbon atoms, a secondary alkyl group of 3 to 20 carbon atoms, a tertiary alkyl group of 4 to 20 carbon atoms, or a cycloalkyl group of 3 to 20 carbon atoms;

15  $R^2$  is a hydrogen atom, a primary alkyl group of 1 to 20 carbon atoms, a secondary alkyl group of 3 to 20 carbon atoms, a tertiary alkyl group of 4 to 20 carbon atoms, a cycloalkyl group of 3 to 20 carbon atoms, an aralkyl group of 7 to 20 carbon atoms, or an allyl group of 3 to 20 carbon atoms;

20  $R^3$  is a hydrogen atom, a primary alkyl group of 1 to 20 carbon atoms, a secondary alkyl group of 3 to 20 carbon atoms, a tertiary alkyl group of 4 to 20 carbon atoms, a cycloalkyl group of 3 to 20 carbon atoms, an aryl group of 6 to 30 carbon atoms, an aralkyl group of 7 to 20 carbon atoms, an alkenyl group of 2 to 20 carbon atoms, an alkynyl group of 2 to 20 carbon atoms, or an allyl group of 3 to 20 carbon atoms; and

$R^1$ ,  $R^2$  and  $R^3$  may be the same or different from one another;  
the phosphine hydrochloride being represented by  
Formula (III):



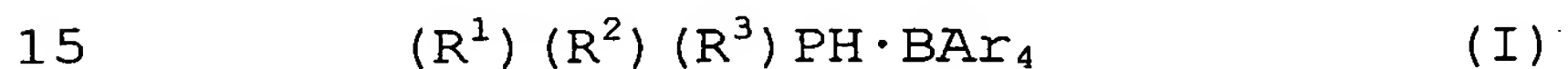
5        wherein  $R^1$ ,  $R^2$  and  $R^3$  are as defined in Formula (II);  
and

reacting the phosphine hydrochloride with a  
tetraarylborate compound represented by Formula (IV):



10        wherein M is lithium, sodium, potassium, magnesium  
halide or calcium halide, and Ar is an aryl group of 6 to 20  
carbon atoms;

the phosphonium borate compound being represented by  
Formula (I):



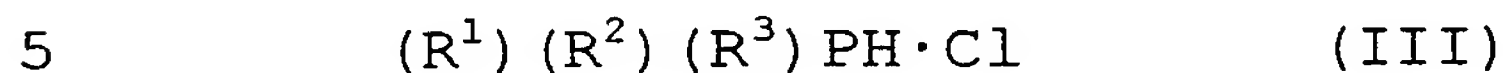
wherein  $R^1$ ,  $R^2$  and  $R^3$  are as defined in Formula (II), and  
Ar is as defined in Formula (IV).

2.        A process for producing a trialkylphosphonium  
20        tetraphenylborate according to claim 1, which comprises:  
reacting a trialkylphosphine with HCl to produce a  
trialkylphosphine hydrochloride, the trialkylphosphine being  
represented by Formula (II):



wherein  $R^1$ ,  $R^2$  and  $R^3$  are ethyl, n-butyl, tert-butyl or cyclohexyl groups, and are the same;

the trialkylphosphine hydrochloride being represented by Formula (III):



wherein  $R^1$ ,  $R^2$  and  $R^3$  are as defined in Formula (II);

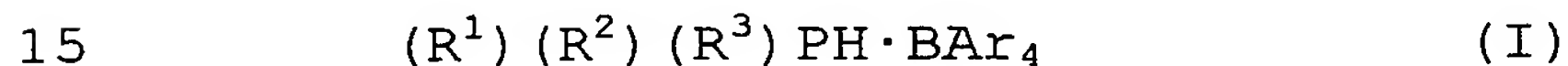
and

reacting the trialkylphosphine hydrochloride with a tetraphenylborate compound represented by Formula (IV):



wherein M is lithium, sodium, potassium, magnesium halide or calcium halide, and Ar is phenyl group;

the trialkylphosphonium tetraphenylborate being represented by Formula (I):



wherein  $R^1$ ,  $R^2$  and  $R^3$  are as defined in Formula (II), and Ar is as defined in Formula (IV).

3.        A process for producing a novel phosphonium borate  
20        compound according to claim 1, which comprises:

reacting a phosphine with HCl to produce a phosphine hydrochloride, the phosphine being represented by Formula (II):



wherein  $R^1$  is a secondary alkyl group of 3 to 20 carbon atoms, a tertiary alkyl group of 4 to 20 carbon atoms, or a cycloalkyl group of 3 to 20 carbon atoms;

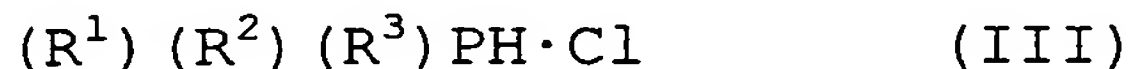
$R^2$  is a hydrogen atom, a primary alkyl group of 1 to 20 carbon atoms, a secondary alkyl group of 3 to 20 carbon atoms, a tertiary alkyl group of 4 to 20 carbon atoms, a cycloalkyl group of 3 to 20 carbon atoms, an aralkyl group of 7 to 20 carbon atoms, or an allyl group of 3 to 20 carbon atoms;

$R^3$  is a hydrogen atom, a primary alkyl group of 1 to 20 carbon atoms, a secondary alkyl group of 3 to 20 carbon atoms, a tertiary alkyl group of 4 to 20 carbon atoms, a cycloalkyl group of 3 to 20 carbon atoms, an aryl group of 6 to 30 carbon atoms, an aralkyl group of 7 to 20 carbon atoms, an alkenyl group of 2 to 20 carbon atoms, an alkynyl group of 2 to 20 carbon atoms, or an allyl group of 3 to 20 carbon atoms; and

$R^1$ ,  $R^2$  and  $R^3$  may be the same or different from one another;

the phosphine hydrochloride being represented by

Formula (III):



wherein  $R^1$ ,  $R^2$  and  $R^3$  are as defined in Formula (II);

and

reacting the phosphine hydrochloride with a tetraarylborate compound represented by Formula (IV):



wherein M is lithium, sodium, potassium, magnesium halide or calcium halide, and Ar is an aryl group of 6 to 20 carbon atoms;

the phosphonium borate compound being represented by  
5 Formula (I):



wherein  $R^1$ ,  $R^2$  and  $R^3$  are as defined in Formula (II), Ar is as defined in Formula (IV),  $R^1$ ,  $R^2$  and  $R^3$  cannot be tert-butyl groups simultaneously and Ar cannot be phenyl group at the same  
10 time, and  $R^1$ ,  $R^2$  and  $R^3$  cannot be cyclohexyl groups simultaneously and Ar cannot be phenyl group at the same time.

4. A process for producing a phosphonium borate compound, which comprises:

15 reacting a phosphine with  $H_2SO_4$  to produce a phosphine sulfate, the phosphine being represented by Formula (II):



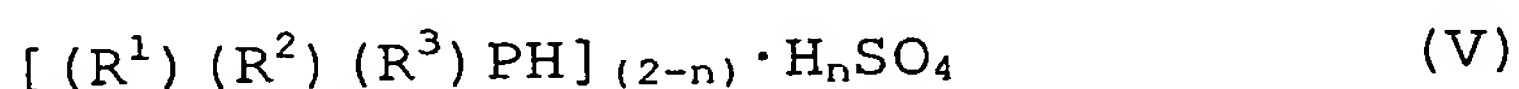
wherein  $R^1$  is a primary alkyl group of 1 to 20 carbon atoms, a secondary alkyl group of 3 to 20 carbon atoms, a  
20 tertiary alkyl group of 4 to 20 carbon atoms, or a cycloalkyl group of 3 to 20 carbon atoms;

$R^2$  is a hydrogen atom, a primary alkyl group of 1 to 20 carbon atoms, a secondary alkyl group of 3 to 20 carbon atoms, a tertiary alkyl group of 4 to 20 carbon atoms, a cycloalkyl

group of 3 to 20 carbon atoms, an aralkyl group of 7 to 20 carbon atoms, or an allyl group of 3 to 20 carbon atoms;

$R^3$  is a hydrogen atom, a primary alkyl group of 1 to 20 carbon atoms, a secondary alkyl group of 3 to 20 carbon atoms, a tertiary alkyl group of 4 to 20 carbon atoms, a cycloalkyl group of 3 to 20 carbon atoms, an aryl group of 6 to 30 carbon atoms, an aralkyl group of 7 to 20 carbon atoms, an alkenyl group of 2 to 20 carbon atoms, an alkynyl group of 2 to 20 carbon atoms, or an allyl group of 3 to 20 carbon atoms; and

$R^1$ ,  $R^2$  and  $R^3$  may be the same or different from one another; the phosphine sulfate being represented by Formula (V):



wherein  $R^1$ ,  $R^2$  and  $R^3$  are as defined in Formula (II), and  $n$  is an integer of 0 or 1;

and

reacting the phosphine sulfate with a tetraarylborate compound represented by Formula (IV):



wherein  $M$  is lithium, sodium, potassium, magnesium halide or calcium halide, and  $Ar$  is an aryl group of 6 to 20 carbon atoms;

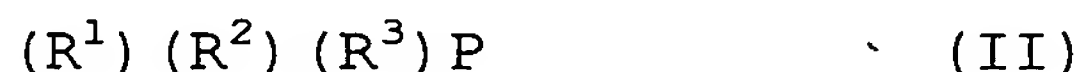
the phosphonium borate compound being represented by Formula (I):



wherein  $R^1$ ,  $R^2$  and  $R^3$  are as defined in Formula (II), and Ar is as defined in Formula (IV).

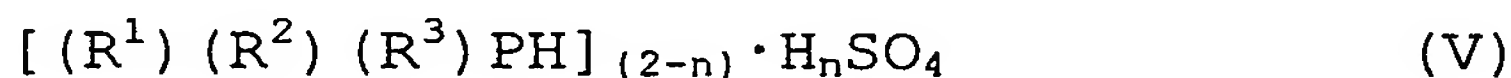
5. A process for producing a trialkylphosphonium  
5 tetraphenylborate according to claim 4, which comprises:

reacting a trialkylphosphine with  $H_2SO_4$  to produce a trialkylphosphine sulfate, the trialkylphosphine being represented by Formula (II):



10 wherein  $R^1$ ,  $R^2$  and  $R^3$  are ethyl, n-butyl, tert-butyl or cyclohexyl groups, and are the same;

the trialkylphosphine sulfate being represented by Formula (V):



15 wherein  $R^1$ ,  $R^2$  and  $R^3$  are as defined in Formula (II), and n is an integer of 0 or 1;

and

reacting the trialkylphosphine sulfate with a tetraphenylborate compound represented by Formula (IV):



wherein M is lithium, sodium, potassium, magnesium halide or calcium halide, and Ar is phenyl group;

the trialkylphosphonium tetraphenylborate being represented by Formula (I):



wherein  $R^1$ ,  $R^2$  and  $R^3$  are as defined in Formula (II), and Ar is as defined in Formula (IV).

5            6.        A process for producing a novel phosphonium borate compound according to claim 4, which comprises:

             reacting a phosphine with  $H_2SO_4$  to produce a phosphine sulfate, the phosphine being represented by Formula (II):



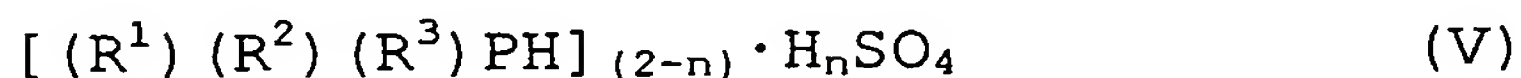
10           wherein  $R^1$  is a secondary alkyl group of 3 to 20 carbon atoms, a tertiary alkyl group of 4 to 20 carbon atoms, or a cycloalkyl group of 3 to 20 carbon atoms;

$R^2$  is a hydrogen atom, a primary alkyl group of 1 to 20 carbon atoms, a secondary alkyl group of 3 to 20 carbon atoms,  
15        a tertiary alkyl group of 4 to 20 carbon atoms, a cycloalkyl group of 3 to 20 carbon atoms, an aralkyl group of 7 to 20 carbon atoms, or an allyl group of 3 to 20 carbon atoms;

$R^3$  is a hydrogen atom, a primary alkyl group of 1 to 20 carbon atoms, a secondary alkyl group of 3 to 20 carbon atoms,  
20        a tertiary alkyl group of 4 to 20 carbon atoms, a cycloalkyl group of 3 to 20 carbon atoms, an aryl group of 6 to 30 carbon atoms, an aralkyl group of 7 to 20 carbon atoms, an alkenyl group of 2 to 20 carbon atoms, an alkynyl group of 2 to 20 carbon atoms, or an allyl group of 3 to 20 carbon atoms; and



$R^1$ ,  $R^2$  and  $R^3$  may be the same or different from one another;  
the phosphine sulfate being represented by Formula (V):



wherein  $R^1$ ,  $R^2$  and  $R^3$  are as defined in Formula (II), and

5     $n$  is an integer of 0 or 1;

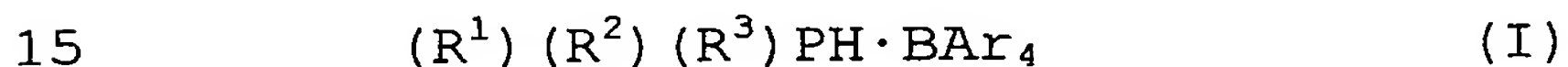
and

reacting the phosphine sulfate with a tetraarylborate  
compound represented by Formula (IV):



10    wherein  $M$  is lithium, sodium, potassium, magnesium  
halide or calcium halide, and  $Ar$  is an aryl group of 6 to 20  
carbon atoms;

the phosphonium borate compound being represented by  
Formula (I):



15    wherein  $R^1$ ,  $R^2$  and  $R^3$  are as defined in Formula (II),  $Ar$   
is as defined in Formula (IV),  $R^1$ ,  $R^2$  and  $R^3$  cannot be tert-butyl  
groups simultaneously and  $Ar$  cannot be phenyl group at the same  
time, and  $R^1$ ,  $R^2$  and  $R^3$  cannot be cyclohexyl groups  
20 simultaneously and  $Ar$  cannot be phenyl group at the same time.

7.    A novel phosphonium borate compound represented  
by Formula (I):



wherein  $R^1$  is a secondary alkyl group of 3 to 20 carbon atoms, a tertiary alkyl group of 4 to 20 carbon atoms, or a cycloalkyl group of 3 to 20 carbon atoms;

$R^2$  is a hydrogen atom, a primary alkyl group of 1 to 20 carbon atoms, a secondary alkyl group of 3 to 20 carbon atoms, a tertiary alkyl group of 4 to 20 carbon atoms, a cycloalkyl group of 3 to 20 carbon atoms, an aralkyl group of 7 to 20 carbon atoms, or an allyl group of 3 to 20 carbon atoms;

$R^3$  is a hydrogen atom, a primary alkyl group of 1 to 20 carbon atoms, a secondary alkyl group of 3 to 20 carbon atoms, a tertiary alkyl group of 4 to 20 carbon atoms, a cycloalkyl group of 3 to 20 carbon atoms, an aryl group of 6 to 30 carbon atoms, an aralkyl group of 7 to 20 carbon atoms, an alkenyl group of 2 to 20 carbon atoms, an alkynyl group of 2 to 20 carbon atoms, or an allyl group of 3 to 20 carbon atoms;

$R^1$ ,  $R^2$  and  $R^3$  may be the same or different from one another;

Ar is an aryl group of 6 to 20 carbon atoms;

$R^1$ ,  $R^2$  and  $R^3$  cannot be tert-butyl groups simultaneously and Ar cannot be phenyl group at the same time; and

$R^1$ ,  $R^2$  and  $R^3$  cannot be cyclohexyl groups simultaneously and Ar cannot be phenyl group at the same time.

8. The phosphonium borate compound according to claim 7, which is di-tert-butylmethylphosphonium

tetraphenylborate.

9. The phosphonium borate compound according to claim  
7, which is tri-tert-butylphosphonium  
5 tetra-para-tolylborate.

10. The phosphonium borate compound according to claim  
7, which is tricyclohexylphosphonium tetra-para-tolylborate.

10 11. The phosphonium borate compound according to claim  
7, which is triisopropylphosphonium tetraphenylborate.

12. Use of a phosphonium borate compound in  
combination with a transition metal, transition metal salt,  
15 transition metal oxide or transition metal complex in  
carbon-carbon bond forming reactions, carbon-nitrogen bond  
forming reactions and carbon-oxygen bond forming reactions  
wherein a transition metal complex having a phosphine ligand  
produces catalytic effects, wherein the phosphonium borate  
20 compound in combination with the transition metal, transition  
metal salt, transition metal oxide or transition metal complex  
is used in place of the transition metal complex having a  
phosphine ligand, the phosphonium borate compound being  
represented by Formula (I):



wherein  $R^1$  is a primary alkyl group of 1 to 20 carbon atoms, a secondary alkyl group of 3 to 20 carbon atoms, a tertiary alkyl group of 4 to 20 carbon atoms, or a cycloalkyl group of 3 to 20 carbon atoms;

$R^2$  is a hydrogen atom, a primary alkyl group of 1 to 20 carbon atoms, a secondary alkyl group of 3 to 20 carbon atoms, a tertiary alkyl group of 4 to 20 carbon atoms, a cycloalkyl group of 3 to 20 carbon atoms, an aralkyl group of 7 to 20 carbon atoms, or an allyl group of 3 to 20 carbon atoms;

$R^3$  is a hydrogen atom, a primary alkyl group of 1 to 20 carbon atoms, a secondary alkyl group of 3 to 20 carbon atoms, a tertiary alkyl group of 4 to 20 carbon atoms, a cycloalkyl group of 3 to 20 carbon atoms, an aryl group of 6 to 30 carbon atoms, an aralkyl group of 7 to 20 carbon atoms, an alkenyl group of 2 to 20 carbon atoms, an alkynyl group of 2 to 20 carbon atoms, or an allyl group of 3 to 20 carbon atoms;

$R^1$ ,  $R^2$  and  $R^3$  may be the same or different from one another;  
and

Ar is an aryl group of 6 to 20 carbon atoms.

13. The use of a phosphonium borate compound according to claim 12, wherein the transition metal is manganese, iron, cobalt, nickel, ruthenium, rhodium, palladium or platinum.

14. The use of a phosphonium borate compound according to claim 12, wherein the transition metal salt is a fluoride, chloride, bromide, iodide, sulfate, nitrate, nitrite,  
5 carbonate, borate, ammonium salt, sodium salt, potassium salt, acetate, trifluoroacetate, acetylacetone salt, hydride salt, sulfide or cyanide of the transition metal as described in claim 13.

10 15. The use of a phosphonium borate compound according to claim 12, wherein the transition metal oxide is an oxide of the transition metal as described in claim 13.

15 16. The use of a phosphonium borate compound according to claim 12, wherein the transition metal complex is a benzonitrile complex, acetonitrile complex, triphenylphosphine complex, ethylene complex, allyl complex, butadiene complex, cyclopentadiene complex, cyclooctadiene complex, cyclooctatetraene complex, carbonyl complex,  
20 dibenzylideneacetone complex, amine complex, ethylenediamine complex, pyridine complex or disiloxane complex of the transition metal as described in claim 13.